Neural Machine Learning I

COMP / ELEC / STAT 502, Spring 2021

Elective course, 3 credits (3 contact hours per week)

Course home page: http://www.ece.rice.edu/~erzsebet/ANNcourse.html
(This website is also linked from Canvas.)
Students are responsible for being familiar with this syllabus, and with the contents of both the above and the Canvas website, and follow the postings as the course proceeds.
The information contained in the course syllabus, other than the absence policies, may be subject to change with reasonable advance notice as deemed appropriate by the instructor.

Class meets: TR 3:10 – 4:30pm Central Time via Zoom (URL to be sent separately)
Instructor: Erzsébet Merényi
email: erzsebet@rice.edu
Office/Phone: DCH 2082, 713-348-3595 but email is preferred during the pandemic
Office hour: by appointment via Zoom
Teaching Assistants and contact information: as posted on the course home page above.
TA advising: as posted on the course home page above, subject to change.

This course will be taught remotely, as a combination of synchronous activities (lectures, office hour, TA advising, via Zoom) and asynchronous components (assignments, exercises, discussions) through CANVAS. The "live-online" environment of synchronous attendance enables real-time questions and discussion during class, as well as instant feedback; students are strongly encouraged to attend in that mode if it is feasible for them. Recording of Zoom classes may be available after the respective classes for those in time zones that prohibit synchronous attendance. In the event technical problems may interfere with recording or with the timely posting of recordings students can rely on lecture notes, recommended reading and other written materials.
I realize that some students attending while away from the campus may not have ready access to some of the desirable infrastructure. In that event, it is important to let me know as early as possible so that we can work together to find alternatives. I also encourage you to communicate with me as soon as possible if you have any concerns, experiences or difficulties that may affect your learning in this class, or for any other reason.

Short course description

Review of major Artificial Neural Network paradigms. Analytical discussion of supervised and unsupervised learning. Emphasis on state-of-the-art Hebbian (biologically most plausible)

learning paradigms and their relation to information theoretical methods. Applications to data analysis such as pattern recognition, clustering (information discovery), classification, non-linear PCA, independent component analysis, with examples and exercises from image and signal processing and other areas.

Brief Sample List of Topics

Introduction: What is an Artificial Neural Network (ANN), defining characteristics
Review of Basics: from Calculus, Information Theory and Statistics
General Machine Learning concepts: supervised and unsupervised learning; training and test data, cross-validation
Associative Memory: recall from partial and noisy samples, stability
Supervised Lerning: Simple and Multi-Layer Perceptrons
Evaluation of Learning and Generalization Performance
Unsupervised Learning: Hebbian learning, PCA nets, Competitive Learning (SOMs, LVQs)
Recurrent nets: Hopfield and Boltzmann Machines, Simulated Annealing
Speeding Up Supervised Learning, and Structure Optimization
Objective Functions for ANN Learning: information theoretical functions
Identifying Independent Sources (Blind Source Separation) with ANNs

A more detailed sample course outline is posted at
http://www.ece.rice.edu/~erzsebet/ANNcourse.html/CourseOutline

Exercises, home works, exam and course project will involve programming in the student's choice of Matlab (preferred), C, R (Fortran also acceptable). Code handouts will be in Matlab.

Detailed Course Schedule

A detailed schedule of class topics will come on-line in a timely manner at the course web site http://www.ece.rice.edu/~erzsebet/ANNcourse.html under Course Schedule along with reading assignments from text book and lecture notes. I will also indicate there when home work assignments are posted in Canvas, along with due dates; post the dates of upcoming tests, and all relevant logistics. The materials (such as lecture notes and home work assignments) indicated in the Course Schedule will be downloadable from Canvas, and you will submit assignments electronically through Canvas.

Pre-requisite

- No previous knowledge of Artificial Neural Nets is assumed.
- Linear algebra (such as in CAAM 335, MATH 355, ELEC 301, ELEC 303, or equivalent), and multivariate calculus (such as in CAAM 336, MATH 321, CAAM 501, or equivalent);
- Probability and statistics (such as in STAT 310, or ELEC/STAT 331 or equivalent);

- Simple information theoretical notions (ELEC 241 or equivalent); These will be briefly reviewed in the course.
- If you have taken (ELEC 531 and (CAAM 583 / ELEC 533 / STAT 583)) or (STAT 615 and STAT 518) you automatically qualify.

Additionally, courses such as the following (or similar) are an advantage: ELEC/COMP 440 or ELEC 535; ELEC 478, 483, CAAM 416, 453; ELEC / CAAM / MECH 508; STAT 413 / 613

Course Materials

The course will be based on Lecture Notes, scheduled as described at the course site http://www.ece.rice.edu/~erzsebet/ANNcourse.html under Course Schedule .

Recommended reading will be selected parts of the following books. All are available at www.amazon.com, or at the Fondren Library at Rice. You can also borrow my copies for short periods of times.

On neural networks

- Frederick Ham and Ivica Kostanic: Principles of Neurocomputing for Science & Engineering. McGraw-Hill, 2001.
- Simon Haykin: Neural Networks. A Comprehensive Foundation. McMillan, New Jersey, 1999. (2nd Edition)
- Christopher M. Bishop: Neural Networks for Pattern Recognition. Oxford University Press, 1995.

On machine learning (neural and other)

- Christopher M. Bishop: Pattern Recognition and Machine Learning. Springer, 2007.

Further suggested reading is listed at the course web site under Course Materials, and occasional articles will be suggested in the Course Schedule and provided in Canvas.

Objectives of the Course

1. Student understanding of concepts, and mastery, of the main types of neural machine learning models and methods, and their applications to data mining, clustering, classification and regression.

2. Student mastery of both theoretical approaches and application of neural network simulations for solving data analysis problems. Understanding and practicing correct methodology for good neural network learning and generalization, and assessment of the quality of the learning (the generalization capability of trained networks).

3. Student competence in communicating the methods and results of data analyses with neural networks.

Assignments, Grading Policies and Other Logistic Requirements

Grades will be made up of the following components, with approximate weights as shown:

25% - Homework assignments
7.5% - Quiz 1
7.5% - Quiz 2
25% - Exam 1
30% - Course Project
5% - Points earned in bonus challenges

This break down is ***subject to change depending on resources that will be available to the instructor for grading***. Parts of points 1. – 4. below may change accordingly.

As of January 8, 2019, the grading / TA support available for this class became insufficient for full grading of individual home works. Therefore, the following innovation was introduced: Students do home works in groups. The groups, formed by self-organization 😊, are permanent throughout the semester. Students in a group work together, agree on, and produce a home work solution and write-up, then submit it as a group (we do group assignments in Canvas). Each student in a group will receive the same grade points for the particular home work unless they state contributions in a proportion different from equal percentage. In each home work, they will state the names of the group members, and the percentages of their contributions if unequal. Pizza Points you can earn by various bonus challenges in home works or tests will be used to boost your final grade.

The home work grouping does not affect quizzes and exams, which will be done individually and will be graded individually. Class projects, however, will be done in groups. At project time students will be allowed to form different groups from the home work groups if they want to.

1. Home work assignments

There will be approximately four or five home works in the first half of the semester. There will be only two home works in the second half of the semester, in order to allow time for the Course Project. The assignments themselves will be posted in Canvas. Home works will be due, by default, before the beginning of class on the due date as specified in Canvas. Due dates will also be shown in the Course Schedule in a timely manner. Solutions from previous years are off-limit. Partial grading may be applied (i.e., grading a randomly selected subset of the homework problems) depending on the number of students and grading support for the course.

You(r group) will be required to upload an electronic copy (a pdf file) to Canvas. You are not required to type everything but if you have parts produced non-electronically you need to scan your hard copy into a pdf file with a reasonably high-quality scanner.

A summary of required formats, file names, and other requirements are posted here in a single file, for your convenience. I will refer to this file as "Logistic Details". Please be sure to thoroughly read and follow. You may save the file for your handy reference; or you can always access it at https://www.ece.rice.edu/~erzsebet/ANNcourse/NML502-LogisticsDetails.pdf

1.1 Late home work policy

Home work will be due on the due date and time posted with the Assignment in Canvas. If the deadline indicated in the Course Schedule should be different, then the deadline posted in Canvas applies. After the due date, but before the late deadline (the "accept until" date in Canvas), home works can be turned in for 50% credit. After sample solutions are handed out, 0% credit will be issued. Should any circumstance prevent electronic submission to Canvas at any time, please *contact me before the assignment is due*, and copy the TA(s). We will work with you to solve the problem. However, please let me and the TA(s) know immediately (by phone if necessary) of any problem accessing Canvas.

2. Tests

Quiz 1 and Quiz 2: approx. 40 - 45 min, closed notes/books/phones/computers, planned as electronic "in-class" style quizzes. (Computers may be used only for writing and submitting the quiz answers.) The exact implementation (multiple-choice form, questions requiring short typed answers, or combination) will be announced well ahead of time.

Midterm exam, Exam 1: The Exam will be take-home, open book and open notes but using restricted time, and other resources (such as internet) will be restricted, and you will be required to give the honor pledge. The exact requirements and details will be given with the exams. Test solutions from previous years are strictly off-limit.

The exact dates of these tests will be posted in the Course Schedule in a timely manner, as well as announced in class approximately two weeks ahead of time. The anticipated *approximate* dates are mid - late February (Quiz 1), mid – late March (Midterm), and early – mid April (Quiz 2). For all tests you will be required to adhere to the Rice Honor Pledge.

3. Course Project

A Project will be done over an approximately four-week period in the second half of the semester. Students will form groups by self-organization 😊. The project groups can be the same or different from the home work groups. Each group will submit a project proposal between approximately March 18 or March 23 (exact date TBD, will be announced in class and will be posted in the Course Schedule). It is anticipated that by that time the major ANN paradigms will have been discussed in class and students will be able to select a project topic, either from a list provided by me, or devise their own. I will review and approve each proposal (or discuss necessary modifications) before students start executing plans. Details, requirements and the characteristics of a successful Project are described here.

4. Bonus challenges will be added to assignments and you can earn "Pizza Points" which will be counted toward your final grade. Additional bonus challenges will be short in-class surveys (one or two questions in a Google form). While the in-class surveys will not count toward your grade in 2021 (in view of students who can only attend asynchronously) you will benefit from instantaneous feedback and discussion.

Missed assignments If you must miss (or be late with) a home work, or a test due to an extraordinary circumstance please notify me and the TA(s), and **make arrangements with me** for completing the missed assignment, *as much ahead of time* as possible. If, in extreme emergency, you are unable to provide advance notice, please let me know as soon as possible afterwards, and I will work with you on a solution accordingly. Please do not ask the TA(s) for extensions, make-up arrangements, and other exceptions. Address all such requests directly to me (but copy the TA(s)).

Other Requirements

In addition to file formats and name requirements, the "Logistic Details" file (above) contains a summary of other logistic requirements such as the procedure that you must follow for disputing / appealing grade points; and email communication with me and TA(s) and graders.

Class Attendance and Absence Policy

Students are strongly advised to attend classes and participate in class activities. Students who must miss a class or assignment because of unavoidable circumstances should consult with the instructor as much in advance as possible so that alternative arrangements may be made.

Expectations Regarding Honor Code, Collaboration, and Citation

In preparing home works, students are encouraged to consult freely any material and anyone. However, each individual (or each home work group) will write and turn in their own solution, which they are expected to understand. If the solution is the result of group work, each group will write the names of the collaborators on their solution. For tests, students will be required to work individually, and adhere to the Rice Honor Code. Solutions from previous years are off-limit. In all work, students are expected to be scrupulous about proper citation of sources (where applicable), as required both as a matter of integrity and formally as a part of the Rice Honor Code.

University Disability Accommodation Policy

The University seeks to foster an environment of broad access and feasibly equal opportunity to education. The Office of Disability Support Services (DSS; Allen Center, Room 111; 713-

348-584; adarice@rice.edu) supports and implements federal guidelines under the Rehabilitation Act of 1973 and the Americans with Disabilities Act. Students with documented disabilities requiring accommodation under Rice's established policies should consult DSS and the instructor; all such consultations and accommodations will be held confidential to the extent feasible.

Use of Machines in the Classroom

Cell phones must be turned off during class unless I ask you to use them for class purposes. If you anticipate the need to take an urgent call, please set your phone to vibration and take the call outside the room. Laptops or other small devices may be used only for specific class purposes such as participating via Zoom or taking notes. If you have an urgent need to be online for other purposes during class time, feel free to do so **. . .** but outside the (Zoom) classroom. If possible please have live camera presence in class, or at least a static picture of you in Zoom, and be available for discussion. I will expect students to be punctual, to dress like in the regular classroom, and to refrain from eating or other distractions during class.